

# Wave Energy

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Worldwide demand for electricity is expected to double within the next 20 years. This demand, combined with commitments to significantly reduce CO<sub>2</sub> emissions within the same time frame, are facilitating the push for clean, socially acceptable methods of generating power.

The ocean is a large, relatively untapped renewable energy resource. The British Department of Trade and Industry has claimed that there are at least 90 million gigawatts of energy in wind driven waves alone worldwide [1]. This may be compared to the 15 thousands gigawatts of energy consumed worldwide. Besides surface wave energy, there are numerous other ways of extracting energy from the ocean. Tidal power includes using

the potential energy created by lunar tides at shorelines and rivers. Marine currents such as the Gulf Stream could be used much like windmills to gather wind energy. Other resources like temperature and salinity gradients are also considered of high potential.

According to London-based Carbon Trust, wave energy can realistically provide over 2,000 terawatts (TWh) of electricity per year--

approximately 10% of global energy needs-- and eventually generate revenues from wholesale power sales in excess of \$50 billion per year. However, according to the Electric Power Research Institute (EPRI) of Palo Alto, CA, a realistic estimate of ocean wave energy potential in the United States indicates approximately 6% of total energy needs with a wholesale market value eventually reaching \$16 billion per year.

Ocean wave energy has significant advantages over other renewable energy resources like wind and solar for the following reasons:

Ocean wave energy is a very predictable and consistent (less intermittent) energy resource which means: (a) fewer technical problems related to grid interconnection; and (b) potential for higher \$/kWh sale price.

Developing ocean energy resources will reduce dependence on fossil fuels (oil, coal, and natural gas), which have limited resources. Also, since ocean energy is not subject to fuel cost increases, this effectively positions ocean energy as a potential hedge against price volatility. Finally, ocean energy technologies produce no emissions of harmful pollutants or greenhouse gases.

Fossil fuels such as coal and oil are not renewable over the span of human generations, and their use may be increasingly limited by environmental concerns over global warming and acid rain. To meet the energy needs of a growing world population, engineers in coming decades will be challenged to generate power economically from renewable energy sources. Despite the fact that nearly 75% of the Earth's surface is covered with water, waves are a largely unexplored source of energy in comparison to the progress that has been made in harnessing the sun and the wind.

Wave energy systems are built to harness energy from waves and transform it into

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electrical power. By absorbing the incoming energy, power modules create an area of calm water behind them, contributing to coastal defense and producing a valuable area for other commercial and recreational marine activities. This protected area can be used to create self-financing harbors and breakwaters. Their installation can bring positive environmental and economic spin-offs, such as protection of threatened areas of coastline or provision of an environment suitable for aquaculture development.

Artificial reefs substantially improve the local marine bio-density, attracting shoals of fish

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and providing habitats for the colonization of commercially valuable species. Wave energy systems can act as these artificial reefs while also providing the potential to improve the local inshore marine harvest. Benefits will be greater in areas currently sparsely populated with marine life and devoid of suitable substrate for settlement.

Converting the mechanical energy of waves into other forms of usable energy (for example electrical energy or compressed air) has inspired new technologies and efforts. According to [peswiki.com](http://www.peswiki.com) there are about 60 companies with a stake in the wave energy industry. There are three major classes of wave energy conversion devices based on how they interact with the ocean [2]:

1- Oscillating Water Columns (OWC) are devices that involve creating a structure on the shoreline such that waves enter and leave a static chamber. The motion of the water pushes air up when it enters and pulls air back as it leaves. This oscillation of air pressure turns a turbine to generate electricity [3].

2- Overtopping Devices consist of a structure that collects incoming waves by creating a reservoir into which only tall waves may crash. Therefore waves must overtop a barrier to be collected. Then the reservoir is emptied out below through a turbine collecting the potential energy of the reservoir.

3- Surface Devices include devices that directly use the motion of the ocean surface. They generally include a floating surface that moves up and down due to the buoyancy force of waves. Tested prototypes include Pelamis of Ocean Power Delivery [4], PowerBuoy of Ocean Power Technologies [5], and Aquabuoy of Finavera [6].

Despite the extreme effort placed on extracting ocean wave energy and the fierce competition that is heating up fast, there are serious challenges associated with a commercially viable ocean wave energy power plant. While there remain difficult open questions on the theoretical side of energy extraction from ocean waves, engineering challenges include, but are certainly not limited to, survivability in the ocean's harsh environment, and the development of extraction and conversion mechanisms suitably adopted for slow reciprocatory motion of the ocean's surface. On the deployment and test side, wave energy companies, particularly United States based ones, are involved with serious regulatory issues as well.

Although still in the early stages of development, wave energy can and will provide enough power to supply a substantial part of the world energy demand. The wave energy industry is sometimes compared with the wind energy industry some 25 years ago when there was neither a unique design, nor a universal agreement on its future path. Wind industry has converged to a unique design over the past quarter of a century and now is a major player in the energy industry. Having learned from the evolution of wind power, wave energy is expected to come into play in a much shorter time period.

[1] UK Department of Trade and Industry “Sustainable Energy Route Maps: Wave Energy” <http://www.berr.gov.uk/files/file27084.pdf>

[2] European Marine Energy Centre. [http://www.emec.org.uk/wave\\_energy\\_developers.asp](http://www.emec.org.uk/wave_energy_developers.asp)

[3] WaveGen. <http://www.wavegen.co.uk>

[4] Ocean Power Delivery. “Pelamis” <http://www.oceanpd.com>

[5] Ocean Power Technologies. <http://www.oceanpowertechnologies.com>

[6] Finavera Renewables. <http://finavera.com>

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